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WEAPONS SYSTEMS EVALUATION GROUP
ODDR&E
Washington 25, D. C.

THIRD VOLUME OF

ENCLOSURE "A"

EVALUATION OF PROGRAMMED STRATEGIC OFFENSIVE SYSTEMS 1964-1967

WSEG REPORT NO. 50

27 December 1960

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Third Volume of
Enclosure "A"
WSEG Report No. 50

H-3282

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APPENDICES "D", "E" AND "F" TO

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ANNEX TO APPENDIX "D"

FALLOUT METHODOLOGY

ANNEX TO APPENDIX "D"

FALLOUT METHODOLOGY

STATEMENT OF THE PROBLEM

1. To describe the method used to calculate fallout casualties, and the rationale for the selection of radiation shielding factors for use in the examples.

DISCUSSION

2. The model used to compute fallout near ground zero for use in the WSEG city fatality model is based directly on the model of WSEG Research Memorandum No. 10, and is identical with that used in the calculations of the Joint Atomic Weapons Planning Manual.

3. The area fallout model is the same as that described in WSEG Research Memorandum No. 5, but uses somewhat more up-to-date values for the parameters, and will be described in more detail.

THE AREA FALLOUT MODEL

4. This model makes use of the fact that fallout wind conditions cannot be predicted in advance of an attack. Therefore (except for the small percentage of fallout which is deposited in the immediate vicinity of ground zero), the areas hazarded by fallout from any given burst point cannot be predicted in advance. It is only known that most of the fallout will come down somewhere in the general vicinity of the burst point (usually within a few hundred miles). The model, therefore, makes the simplifying assumption that the actual location of the fallout is randomly located somewhere in the general vicinity of the burst point. For purposes of the calculation the total national area is divided into a number of regional sub-areas and the expected fallout casualties in each sub-area are computed as if the fallout from each detonation were randomly located within the sub-area. This method of calculation together with some simplifying mathematical

formulas is described in WSEG Research Memorandum No. 5. The results of this computational technique have been checked on several occasions against detailed calculations done both inside and outside WSEG, and have been found to be in good agreement with the results obtained from the more detailed analysis.

5. However, since the publication of RM-5, a number of refinements have occurred in the state of the art in fallout calculation, so that it is no longer appropriate to make use of exactly the same dose vs. area relations to describe fallout areas from a single detonation. For this reason the basic input data for the model have been revised. The basic dose vs. area data used in the present calculation are no longer based on the old RAND Memorandum RM-1969, but are based on the more recent estimates in WSEG Research Memorandum No. 10.

6. The dose vs. area results in Memorandum No. 10 depend not only on yield, but on wind velocity, and wind shear as well. In order to obtain a typical or reasonable estimate of this relation the dose vs. area relation was based on an expected value analysis in which the expected area of each dose contour was computed using a mixture of weapon yields from 1 to 20 megatons and a mixture of wind velocities and wind shear conditions. Actually the results in terms of percent casualties for a given number of megatons are not very sensitive to the differences involved in the mixture. The mixture was used only to give as typical an estimate of casualties as possible.

7. The doses used in the calculation are based on the maximum biological dose contours of RM-10, which are essentially equivalent to 96-hour cumulative doses integrated from the time of arrival of the fallout. The yield mixture chosen contained equal amounts by megatonage of 1, 3, 10, and 30 megaton weapons. The wind conditions used contained 0, 10, 20, 40, and 60 knot winds

with appropriate probabilities and appropriate wind shear distribution to correspond to the spring or fall season in the U.S.

8. The resulting dose vs. area relation per megaton for 100 percent fission yield at random in a very large area is:

AREA WITH DOSE GREATER THAN	
Square Miles	Roentgen
37,600	1
26,000	3
16,000	10
9,700	30
4,900	100
2,200	300
900	1,000
230	3,000
32.5	10,000
1.5	30,000

To get corresponding results for other fission yields, all doses are multiplied by fraction of fission yield.

9. These figures ignore additional effects due to induced activity

On the other hand, the figures are based on the DASA estimate of hypothetical h + 1 total area x dose rate per megaton fission which is about 2.6 x 10^6 roentgen per hour x square miles/MT. According to a recent preliminary calculation of fractionation of radioactive gases by ...DL this estimate could be a little high.

A smooth curve based on the data in the preceding table has ...used to calculate the expected distribution of dose vs. area ... large number of weapons are dropped at random in the same ...area. The calculation was carried out by machine compu... in the following way. Let $P_y(D)$ be the probability ...ution of dose, D , at a random point for y megatons

per unit area. Then the probability distribution for $2y$ megatons, $P_{2y}(D)$, is given by:

$$P_{2y}(D) = \int_{0}^{\infty} P_y(D_1)\, P_y(D - D_1)\, dD_1 .$$

This formula was evaluated in an iterative procedure which began with the dose area relation given above and built up by successive factors of two to the realistic attack densities.

11. Figure 1 shows the results of this integration, in heavy lines plotted on log normal graph paper for comparison with the log normal approximation of RM-5. The parameters of the simplified formula of RM-5 were adjusted to give a good fit to the results of the integration for 1.2 tons fission/mi.^{2}. The light lines in Figure 1 show how this approximation as used in the analysis compares with the results of the detailed calculation. While the accuracy of the fit is inevitably not perfect, it seems sufficiently good for the purpose of the analysis.

12. The calculation of area casualties by the method of RM-5 depends on breaking the area to be attacked into more or less homogeneous, contiguous sub-areas. In order for valid answers to be obtained it is necessary that the sub-areas be sufficiently large that they exceed the size of individual fallout patterns yet small enough that they can properly allow for major differences in attack density from one area to another. Sample calculations for the United States were carried out using individual states as the sub-areas. The calculations were then repeated using only twelve major regional areas in the country. Even for optimized attacks the differences in results were not more than 1 to 2 percent in the estimated population casualties. Consequently it was concluded that the use of sub-areas as small as states did not lead to serious errors in the results, and these areas were used in all the calculations of this report.

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FIGURE 1

PERCENT AREA FREE OF DOSES
IN EXCESS OF INDICATED VALUE

[redacted]

PERCENT AREA FREE OF DOSES IN EXCESS OF INDICATED VALUE

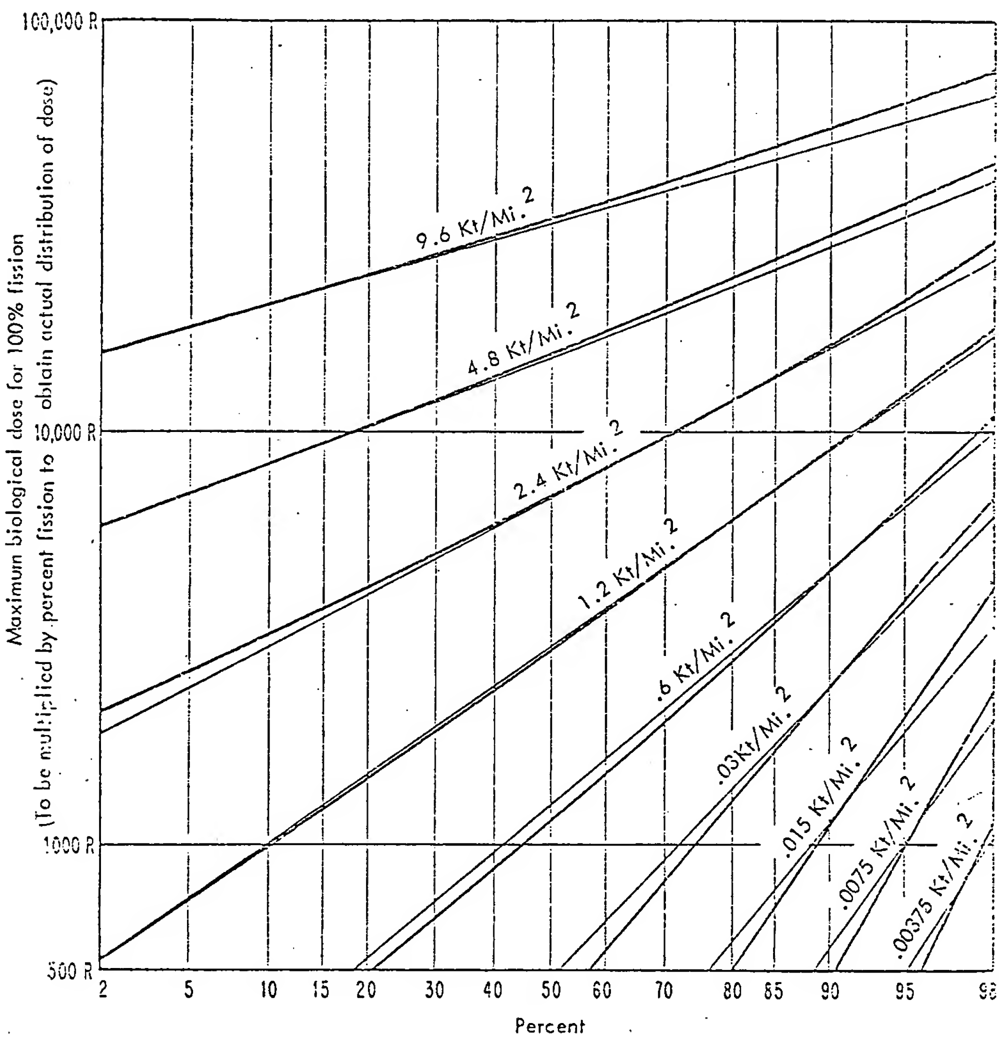

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FIGURE 1
ANNEX TO
APPENDIX "D" TO
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13. There are a large number of large cities on or near the eastern coast of the United States. Because the prevailing wind from these cities would often carry fallout from these targets out over the Atlantic Ocean, it was decided not to include area fallout from weapons on these cities in the calculation. However, the omission of fallout from these targets as it turns out did not significantly reduce estimated casualties.

SELECTION OF SHIELDING FACTORS

14. The selection of shielding factors for calculations of this type is always somewhat arbitrary, since the actual factors which should be applied depend not only on the available shelter, but also on the behavior patterns of the population. The specific distribution of shielding factors used in this calculation for the unsheltered population has a median residual number of .34 with a maximum of .50 and a minimum of about .05. This is intended to correspond to the performance of a relatively undisciplined population, making reasonable use of readily available shelter. Best available residential shielding factors estimated for CCDM by DASA correspond to slightly better shielding factors, giving residual numbers about 30 to 50 percent lower than these. The difference between these two sets of numbers is intended to reflect the failure of a real population to find and remain in the areas of best available shelter. The uncertainties concerning the shielding factors for this unsheltered case, even though they are quite large, are not enough to introduce major errors in the estimated casualties.

15. However, the shielding factors used for the sheltered case are much more uncertain. Since the purpose of the analysis of a sheltered case in the United States is to compare the effectiveness of shelters with active air defense and offensive counterforce systems, it was decided to use a conservative estimate of

the effectiveness of a shelter program. In this way, if the result of the comparison proves unfavorable to offensive counterforce systems the result cannot be attributed to an overestimate of the effectiveness of shelters.

16. The shelter program considered provides shelters which give radiation shielding factors in excess of 500, corresponding to residual numbers less than .002. However, it would be unrealistic to use such a residual number as a single time averaged result because the population cannot remain permanently in the shelter. The specific time average residual number of .03 used as the median in the sheltered case can be obtained by continuous occupancy of the shelter for about one month with little or no shelter thereafter. The same residual number can also be achieved in a large number of other ways which are probably considerably more likely. For instance, continuous occupancy of the shelter for ten days followed by intermittant exposure outside the shelter equivalent to about eight hours a day with normal environmental shielding, for about the next three months, produces about the same time averaged residual number. If shelters are available, and are adequately stocked, as they can be, with provisions for about one month of continuous occupancy, then it is clear that residual numbers considerably better than .03 can be obtained. Thus the use of a median residual number of .03 for the sheltered case seems to represent a clearly conservative estimate of the effectiveness of shelters. That is, the effectiveness of the shelters should actually be considerably better than this.

17. On the other hand, it is not at all clear how much better the shelter performance might actually be. If one carries out a simple calculation of dosage that might be received by a really well-disciplined population, very large improvements appear to be possible. For instance, if very good shelters, RN .0005 or better, were occupied continuously for one month followed by

intermittent daily exposure of not more than eight hours a day for several months in an area with normal environmental shielding where effective decontamination had reduced doses by about a factor of three, then a time averaged residual number of about .0015 which is twenty times better than the .03 could be obtained in principle. While such behavior might be very realistic for a select group, it is not at all clear that such well-disciplined behavior could ever be obtained by the bulk of the national population. Consequently, the use of such shielding numbers might result in a gross overestimate of the effectiveness of shelters.

18. Moreover, the calculations indicated above are based only on the effects of external gamma radiation in the production of fatalities within a month or so. As a shelter program becomes more effective in protecting the population against this primary hazard (which for an unsheltered population is by far the most serious problem), other hazards which previously were of lesser importance begin to create a comparable threat.

19. While it is not easy to estimate quantitatively the importance of these factors they do create problems which tend to reduce the effectiveness of a shelter program in achieving what otherwise might be its ultimate capability. Two of these problems, specifically leukemia and sterility, merit special consideration.

20. There is an indication that even if the human exposure to radiation is kept low enough to avoid serious radiation sickness, the cumulative result of lower doses over a longer period of time can produce sterility. This concept is based on a well-controlled and documented sequence of experiments with male Beagle dogs, which demonstrated that a total cumulative dose in excess of 350 roentgens produced permanent sterility in the dogs, regardless of the exposure rate so long as the dose per week exceeded 15 roentgens. Since the other biological responses of Beagles to

radiation seem to parallel quite closely the human response it seems likely that such a sterilization would also occur in humans. This effect would be most important in a well-disciplined society where exposure was kept sufficiently low to avoid sickness, but where the total cumulative dose could be as high as 1000 roentgens.

21. A second problem which is important where protection from the external gamma radiation is quite good, results from the ingestion of Sr^{90}. Sr^{90} is chemically quite similar to calcium, so this radioactive contaminant enters the food cycle and tends to lodge in the bones. The resulting radiation of the bone marrow can produce leukemia.

22. An average attack density of about 1 MT per thousand square miles, which would be about 3000 MT total in the United States, would be estimated to produce Sr^{90} per square mile. Using data from the United Nations Scientific Committee on Effects of Atomic Radiation this density of Sr^{90} would be expected to produce leukemia after many years in about 1/2 percent of the population. However, if the attack tended to be more concentrated in the heavily populated areas of the country the incidence of leukemia would probably be greater by about a factor of two. These estimates assume that survivors of the attack are able to maintain a diet in which calcium is obtained primarily through milk. On the other hand, if the attack density were much higher, perhaps as high as 6000 MT total, then the percentage of livestock surviving the early gamma radiation would probably be so small that the basic diet after the attack would have to be a vegetarian diet with emphasis on grains, potatoes, and vegetables. In this case the Sr^{90} to calcium ratio in the diet would be higher by about a factor of 2 due to the heavier attack and by an additional factor of 6 because of the absence of the cows which otherwise would impose a selective filtering against the Sr^{90}. In this case

the percentage of leukemia in the population might be as high as 5 percent. Of course, these effects can be somewhat reduced by appropriate countermeasures. Deep plowing of the soil might decrease the Sr^{90} content of the food produced by a factor of 2 to 6. But this is an expensive operation requiring special equipment, and it is likely to seriously decrease productivity. Addition of calcium to the soil might also help, but this would require many tons per acre.

23. Clearly the problems of health and survival for the population become progressively more difficult as the attack density is increased even if one ignores entirely the effects of early gamma rays in producing direct casualties. Thus, while it is possible in principle to obtain very high shielding factors against early gamma radiation, it is not at all clear that the increase in the number of survivors would be nearly as large as one might estimate where only the effect of the early gamma radiation is considered.

24. The shielding factors selected for the sheltered case were chosen to be sufficiently conservative that it is almost certain that a well-organized shelter program could achieve them, and probably do considerably better. However, it is by no means clear how much better performance could actually be achieved because of the compounding of other factors which complicate the problems of health and survival for those who escape excessive exposure to the early radiation.

25. The casualty figures computed for the Soviet Union in this study are done in two ways, one using the shielding distribution for the unprepared case and one using a shielding distribution in which 40 percent of the urban population and 20 percent of the rural population are credited with a shelter posture, like that used in the sheltered case for the U.S. This second posture may

very well correspond closely to the present Soviet posture, and is used in Enclosure "A" to illustrate effects in the Soviet Union. If at some future date the Soviets adopt a more extensive shelter program, casualties would, of course, be considerably less than estimated here.

26. In the limit of a perfect shelter and civil defense program, the potential damage which might contribute to the deterrence of Soviet hostilities, might have to be measured primarily in terms of the damage to urban industrial floorspace (which is also shown). However, destruction of livestock, denial of farm land by radioactive contamination (and the inconvenience of prolonged occupancy of crowded shelters) would also be pertinent factors.

27. The level of attack required to produce heavy casualties in sheltered rural population as a result of blast or direct effects of nuclear weapons is extremely high, probably more than a hundred times that required for similar fatality levels in the urban population. On the other hand, it is not generally believed that potentially heavy casualties in the rural population are necessary for deterrence.

28. Since only about 30 percent of the population of the USSR resides in urban areas, population casualties much above the 30 percent level are very difficult to achieve if radiation effects are not considered. On the other hand, heavy casualties in the urban population can be achieved at relatively low force levels even when only the effects of blast are considered. Sheltering of the urban population in blast hardened shelters of about 100 psi might increase the force level required to obtain heavy casualties in this group by perhaps a factor of 4. However, since the force level required to obtain 30 percent casualties is not very high this would not greatly increase the requirements for deterrence.

39. Only if the urban population were evacuated and sheltered in high quality, long occupancy, shelters, or if a high level of casualties were required in a well-sheltered rural population does the force level needed to produce the required casualties become really large. In these cases the force levels become so large that it seems more appropriate to measure the damage required for deterrence in terms other than direct human casualties. Under these circumstances other measures of damage such as urban industrial floorspace appear more appropriate.

APPENDIX "E" TO ENCLOSURE "A"

THE FEASIBILITY OF ACHIEVEMENT OF COUNTERFORCE OBJECTIVES

[redacted]

APPENDIX "E" TO ENCLOSURE "A"

THE FEASIBILITY OF ACHIEVEMENT OF COUNTERFORCE OBJECTIVES

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TABLES (Cont'd)

FIGURES

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APPENDIX "E" TO ENCLOSURE "A"

THE FEASIBILITY OF ACHIEVEMENT OF COUNTERFORCE OBJECTIVES

INTRODUCTION

1. The purpose of this Appendix is to explore the potential value and the limitations of employment of U.S. systems for the purpose of blunting the effect of nuclear attacks on the United States.

2. The fact that delivery of a very small fraction of the Soviet nuclear forces estimated for the time period of this study is sufficient to inflict unprecedented levels of devastation in the U.S. has been demonstrated in Appendix "D". This fact raises the question of whether it will be possible for the U.S. to prevent unacceptable destruction to the U.S. through the employment of counterforce systems.

3. There are two main contexts which must be considered: the case of U.S. initiative in which U.S. offensive forces may be able to attack most enemy forces prior to their launching; and the case of Soviet initiative in which only a residual part of the Soviet force is subject to attack by U.S. weapons.

4. In addition to U.S. offensive forces, passive civilian defense measures such as fallout shelters, as well as active defenses against manned aircraft and ballistic missiles, must also be considered since they contribute to the same objective of blunting the effectiveness of attacks on the United States.

5. In order to assess the value of various methods of reducing the effect of Soviet attacks on the United States, we shall concentrate primarily on U.S. population fatalities as an indicator of U.S. national damage produced by Soviet attacks. Other

indicators of national damage such as destruction of industry, transportation, communications, or government, while also worthy of consideration, are largely correlated with population fatalities. In any event these other measures, if included, would only serve to increase the estimates of total national damage above the estimate based on population fatalities alone so that the use of population fatalities can be justified as giving a lower limit to the actual total national damage however it might be measured.

DISCUSSION OF AN EXAMPLE

6. In order to give the reader some appreciation of the contribution of U.S. counterforce which can be expected, the discussion will begin with the treatment of a particular example. While it must be recognized any single example is necessarily based upon many assumptions which are open to debate, it is felt that the present example is not unrealistic for the time period of this study. In any event, the subsequent discussion will treat many variations of assumptions, the sensitivity to the assumptions, as well as ultimate limits.

7. The example chosen is a case in which the Soviets take ..e initiative. The assumed Soviet force posture is given in ..ble I, which presents numbers of long-range strategic weapons .. inventory, the configuration of the forces, the fractions of .. bases of each weapon whose locations are assumed known to .. U.S. with sufficient accuracy to permit targeting, the frac- .. of each force for which launching can be commenced in the ..t half to three-quarters of an hour assuming preparation ..ensurate with a Soviet initiative situation (i.e., the frac- .. which can be launched without any interference from a U.S. ..terforce response), the fraction of each force for which ..h is ordered which is actually delivered to the target, and ..ly the yield of the weapons.

TABLE I

SOVIET FORCE POSTURE EXAMPLE

Weapon System	Configuration	Number in Commission	Fraction of Bases Whose Location Known Well Enough to Target	Fraction of Force Ready for Launch in First 1/2-3/4 Hour in Initiative Situation	Deliverable Fraction Reliability x Penetrability
ICBM	Soft, 3 per aim point	200	60%	70%	.7 x 1.0 = .7
	100 psi, 1 per aim point	200	50%	80%	
	Land mobile	200	10%	50%	
SLBM	30% in port among 17 sub bases	300	100%	70% of subs not in port	.7 x 1.0 = .7
Bombers	Distributed among 100 airfields	400	90%	40%	.9 x .4 = .36

8. To illustrate what might be accomplished by a U.S. counterforce strike subsequent to Soviet initiation of hostilities, it is assumed that the U.S. immediately executes a counterforce strike against the residual target system.

9. The residual target system -- the expected numbers of weapons remaining from the initial wave of the Soviet attack distributed among the known bases -- is shown in Table II, together with the vulnerability assumptions and overall single-shot kill probabilities for the postulated U.S. counterforce weapon.

TABLE II

RESIDUAL TARGET SYSTEM OF EXAMPLE

Soviet Weapon		Expected Remaining Targetable Weapons	Known Aim Points	Assumed Vulnerability
ICBM:	Soft 3/aim point	36	40	VN 11-Q-6
	100 psi 1/aim point	20	100	100 psi
	Land mobile	10	20	VN 11-Q-6
SLBM		90	17	VN 17-P-0
Bombers		216	90	VN 11-Q-6

11. The first wave of the Soviet attack, however, leads to an expectation of about 1600 fission megatons delivered, and the non-targetable residue of Soviet forces is expected to ultimately deliver another 430 megatons. Thus, while the U.S. counterforce strike effected a dramatic reduction in the targetable residue of Soviet forces, the overall effect was only a reduction from about 3000 MT to about 2100 MT total delivered against the U.S.

12. To indicate the significance of these numbers for U.S. population fatalities, Table III summarizes the results, and presents expected U.S. population fatalities under several assumptions concerning Soviet targeting doctrine. The first doctrine is a pure military targeting doctrine, the second commits 80 percent of the Soviet force to military targets in the U.S. and 20 percent to population targeting, while the third case allocates one-third of the Soviet force to population targeting. The population fatalities for these cases are obtained from Figure 4 of Appendix "D".

TABLE III

SUMMARY OF RESULTS OF EXAMPLE

		PERCENT U.S. FATALITIES Soviet Attack Doctrine		
	Fission Megatons	Pure Military	20% Against Population	One-third Against Population
Expected Total Deliverable Yield From All Soviet Forces	3000	91%	95%	96%
Expected Total Deliverable Yield From Non-Targetable and First Wave Soviet Forces	2030	78%	88%	89%
Expected Total Deliverable Yield Surviving U.S. Counterforce Attack (Including Non-Targetable and First Wave Forces)	2120	80%	89%	90%

13. It is clear from these results that, for this example at least, the effect of the U.S. counterforce strike, while perceptible, cannot be regarded as a dramatic improvement for the U.S.

14. It is furthermore clear that no significant improvement in this situation would be effected by improving the quality or number of U.S. counterforce weapons over the weapons assumed in this example, since the ultimate limit is set by the non-targetable Soviet forces which by themselves produce U.S. fatalities within one or two percent of the results for the counterforce capability assumed in the example.

15. Even if the United States were to take the initiative in the present example, it would not fare much better. In the present example, the non-targetable Soviet forces alone contain a total expected delivery capability of megatons, so that execution of even a hypothetically perfect U.S. initiative attack which completely destroyed all targetable Soviet forces would leave a surviving Soviet force capable of delivering over a thousand megatons fission. Furthermore, under these circumstances (U.S. initiative attack), it seems reasonable to suppose that the Soviets might retaliate against our population, in which case they could exact a toll of more than 80 percent U.S. fatalities with their surviving force. Even a Soviet retaliatory attack with this surviving force which devoted only 50 percent to population would cause 75 percent fatalities, and if as little as one-third of their surviving force were targeted against population, 70 percent U.S. fatalities would result.

16. The remainder of this Appendix will attempt to demonstrate that the situation which obtains for the preceding example is not an isolated one, but is rather the general case.

17. A number of different illustrative Soviet postures have been chosen for the evaluation. In addition, in order to produce a convincing appraisal of the limitations of counterforce, the conditions upon which the following discussion is based have been deliberately biased in a direction which favors the success of U.S. counterforce efforts. As a result, the success of U.S. counterforce in a realistic situation can confidently be expected to be lower than indicated here, provided the Soviets can launch their surviving weapons against the U.S. (It is, of course, conceivable that U.S. counterforce might sufficiently disrupt the Soviet command and control system as to prevent the launch of any surviving Soviet weapons. The following evaluation is solely concerned with the effectiveness of counterforce directed against enemy weapons, and consequently is based upon the assumption that no such failure of Soviet command and control occurs.)

REPRESENTATIVE SOVIET FORCE POSTURES

18. In order to study the counterforce employment of U.S. weapon systems, it is necessary to postulate the Soviet offensive force posture against which the U.S. systems are to be employed. Because of present uncertainties concerning future Soviet strategic force postures, a number of different postures have been chosen for the Soviet Union to be representative of the possibilities in the time period of 1963-1967.

[redacted]

20. In addition to simply the number of Soviet weapons, it is necessary to delineate various postures that the Soviets might adopt for the basing of these weapons. The figures in Table IV are not intended, therefore, to be accurate intelligence estimates of future Soviet postures, but rather to present illustrative figures for purposes of analysis.

21. Six different missile postures are shown for each time period. These six postures are:

a. I - Soft. The majority of land-based missiles in this case are deployed in a soft configuration with three missiles per aim point.

b. II - Hard. The majority of the land-based missiles in this case are in hardened sites.

c. III - Mobile. Mobile land-based missiles are introduced in the 1965 and 1967 time periods. It is assumed that 10 percent of these mobile missiles can be targeted in a counterforce strike.

d. IV - Dispersed. Dispersed (one per aim point) but still soft missiles are included in the inventory.

e. V - Fast Reaction. In this case it is assumed that 50 percent of the missiles and 25 percent of the bombers can be launched prior to the impact of our counterforce missiles.

f. VI - Accelerated. Larger numbers of land-based missiles are included and all types of siting are also included.

TABLE IV

REPRESENTATIVE SOVIET STRATEGIC OFFENSIVE FORCE POSTURES 1963-1967

WEAPON SYSTEM	CONFIGURATION	(I) SOFT			(II) HARD			(III) MOBILE		(IV) DISPERSED		(V) FAST REACTION			(VI) ACCELERATED		
		1963	1965	1967	1963	1965	1967	1965	1967	1965	1967	1963	1965	1967	1963	1965	1967
ICBM	Soft, 3 per Aim Point	300	600	900	100	100	100	300	300	300	300	300	500	700	200	200	200
	Soft, 1 per Aim Point	---	---	---	---	---	---	---	---	200	400	---	---	---	---	200	400
	100 psi	100	100	100	300	500	500	100	100	100	100	100	100	100	200	400	400
	300 psi	---	---	---	---	---	200	---	---	---	---	---	---	---	---	---	200
	Land Mobile	---	---	---	---	---	---	200	400	---	---	---	---	---	---	200	400
SLBM	50% in Port Among 17 Submarine Bases	210	330	450	210	330	450	330	450	330	450	210	330	450	210	330	450
Bombers	Distributed Among 100 Airfields	600	500	400	600	500	400	500	400	500	400	600	500	400	600	500	400

TABLE IV (Continued)

	(I) SOFT			(II) HARD			(III) MOBILE		(IV) DISPERSED		(V) FAST REACTION			(VI) ACCELERATED		
	1963	1965	1967	1963	1965	1967	1965	1967	1965	1967	1963	1965	1967	1963	1965	1967
ICBM Detectability (%)[a]	90	90	90	90	90	90	90/10	90/10	90	90	90	90	90	90/10	90/10	90/10
Reaction (%Missiles/%Bombers)[b]	0/5	0/5	0/5	0/5	0/5	0/5	0/5	0/5	0/5	0/5	50/25	50/25	50/25	0/5	0/5	0/5
Expected Total Delivered Fission Yield if Unattacked (MT)																
Expected Total Delivered Fission Yield from Non-Targetable Elements (MT)																

a/ Percent of Soviet land-based missile sites whose location is known with sufficient accuracy to permit targeting prior to hostilities. 90/10 refers to capability of targeting 90 percent of fixed sites and 10 percent of mobile sites.

b/ Percent of Soviet missiles and bombers that could be launched prior to destruction by U.S. missiles.

22. It has been assumed in these cases that 90 percent of the fixed enemy land-based missiles have locations which are known to the United States with sufficient accuracy so that they may be targeted. This is a somewhat optimistic assumption and has been made in order to determine the limit of the greatest degree of success which one could hope for, for counterforce strikes. In the event that we are not, in fact, able to detect this large a fraction of Soviet missile sites, the effectiveness of U.S. counterforce strikes will, of course, be reduced.

23.

TABLE V

U.S. INITIATIVE CASE

24. In order to explore the potential value as well as the limitations of U.S. initiative counterforce attacks, calculations for a number of hypothetical attacks on the preceding representative Soviet force postures have been performed. In order to simplify the calculations each attack was performed entirely by a single idealized U.S. weapon system rather than by a mixture of U.S. systems. Although any actual case would, of course, involve a mixture of many U.S. weapons of diverse characteristics, the present procedure of considering only ideal pure systems serves adequately for investigation of the possibilities and limitations of U.S. initiative attacks.

25. For each particular case calculated (consisting of a particular number of U.S. weapons against a particular Soviet posture), the U.S. weapons were optimally targeted against the Soviet force to minimize the U.S. fatalities which could be produced by the surviving Soviet force. The U.S. fatalities which then result from retaliatory employment of the surviving Soviet force against U.S. population serve to measure the accomplishment of the U.S. initiative counterforce attack.

26. The fatality calculations are based on the methods and results of Appendix "D" to this Enclosure, and are estimates of direct fatalities due to blast and fallout only. Because of the additional effects of firestorms, and indirect effects caused by disorganization of society, destruction of communications, genetic damage, destruction of livestock, etc., these fatality estimates should be regarded as underestimates of the ultimate toll.

28. Figures 1 through 3 present the consequences, in terms of U.S. fatalities produced by surviving Soviet forces, of these hypothetical U.S. initiative attacks on the representative Soviet force postures given in Table IV for the years 1963, 1965, and 1967.

29. The general behavior of the curves of Figures 1 through 3 consists of a fairly rapid initial reduction in U.S. population fatalities with increasing numbers of U.S. weapons employed in the initiative attack, followed by decreasing effectiveness as the numbers increase further, and finally flattening out at a constant level of casualties which is not diminished with further increases in U.S. weapons. This lower limit to the population fatalities corresponds to the residue of non-targetable Soviet forces -- the on-station submarine-launched ballistic missiles, the alert or non-targetable fraction of manned bombers (5 percent), the assumed 10 percent of fixed-based missiles of unknown location, and the forces which escape prior to impact of the U.S. weapons in the fast reaction case and 90 percent of the mobile force in the mobile case.

30. In order to illustrate the variation of results with assumed U.S. weapons characteristics, Figure 4 presents the results for the year 1965 for the same yield, CEP, and reliability, but for the case where the weapon is not assumed to be reprogrammable. The ultimate limits for this case are, of course, the same as if the weapon were reprogrammable, since the limits correspond

FIGURE 1

EFFECTIVENESS IN PREVENTING U.S. FATALITIES OF HYPOTHETICAL U.S. INITIATIVE ATTACKS ON REPRESENTATIVE SOVIET FORCE POSTURES (CASE: YEAR 1963)

FIGURE 2

EFFECTIVENESS IN PREVENTING U.S. FATALITIES OF HYPOTHETICAL U.S. INITIATIVE ATTACKS ON REPRESENTATIVE SOVIET FORCE POSTURES (CASE: YEAR 1965)

FIGURE 3

EFFECTIVENESS IN PREVENTING U.S. FATALITIES OF HYPOTHETICAL U.S. INITIATIVE ATTACKS ON REPRESENTATIVE SOVIET FORCE POSTURES ~~(CASE: YEAR 1967)~~

FIGURE 4

EFFECTIVENESS IN PREVENTING U.S. FATALITIES OF HYPOTHETICAL U.S. INITIATIVE ATTACKS ON REPRESENTATIVE SOVIET FORCE POSTURES (CASE: YEAR 1965)

FIGURE 5

EFFECTIVENESS IN PREVENTING U.S. FATALITIES OF HYPOTHETICAL U.S. INITIATIVE ATTACKS ON REPRESENTATIVE SOVIET FORCE POSTURES (CASE: YEAR 1965)

EFFECTIVENESS IN PREVENTING U.S. FATALITIES OF HYPOTHETICAL U.S. INITIATIVE ATTACKS ON REPRESENTATIVE SOVIET FORCE POSTURES

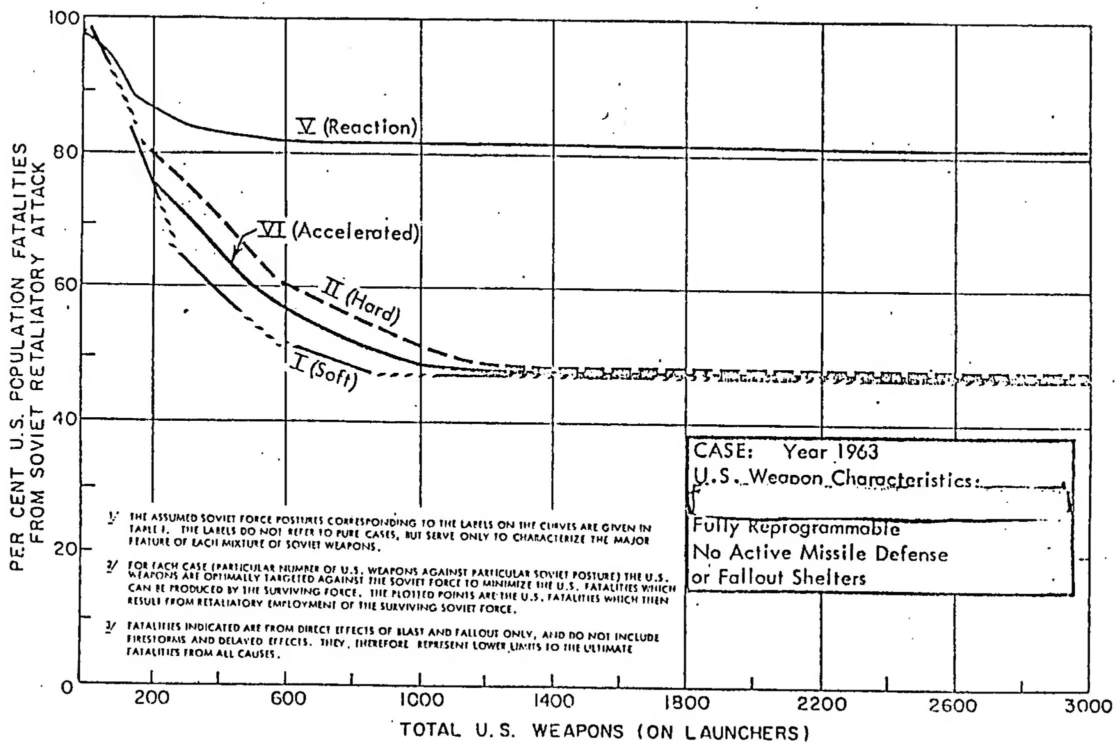
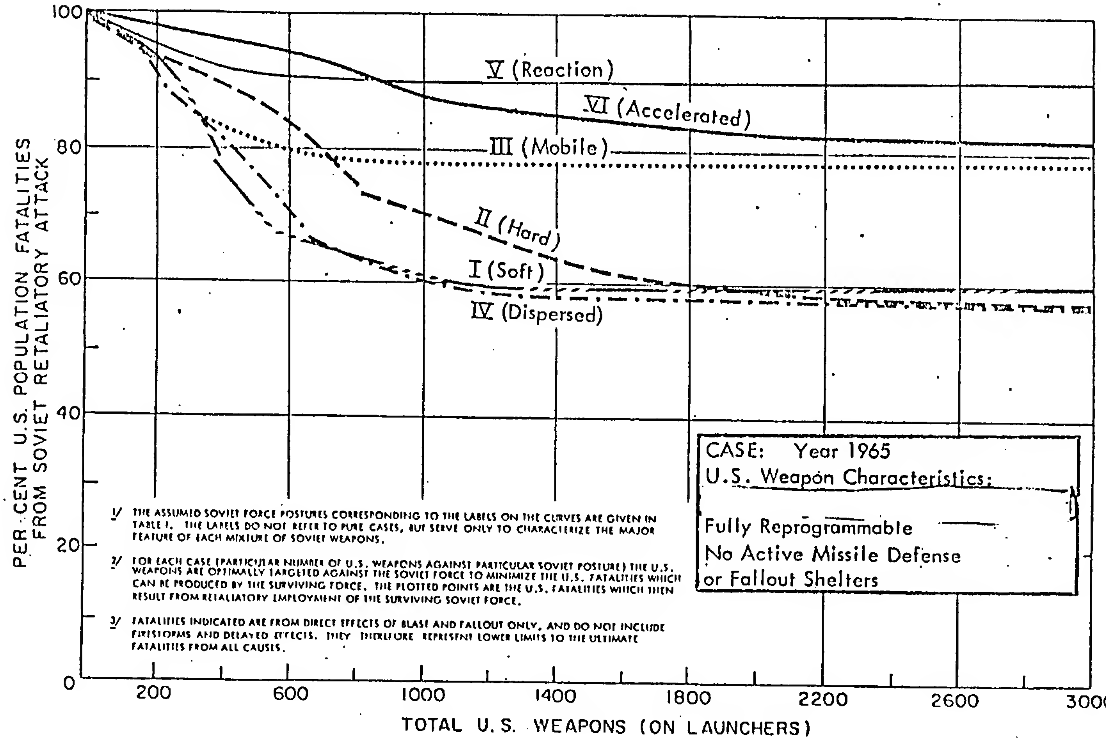


FIGURE 1
APPENDIX "E" TO
ENCLOSURE "A"
WSEG REPORT NO

EFFECTIVENESS IN PREVENTING U.S. FATALITIES OF HYPOTHETICAL U.S. INITIATIVE ATTACKS ON REPRESENTATIVE SOVIET FORCE POSTURES



1/ THE ASSUMED SOVIET FORCE POSTURES CORRESPONDING TO THE LABELS ON THE CURVES ARE GIVEN IN TABLE I. THE LABELS DO NOT REFER TO PURE CASES, BUT SERVE ONLY TO CHARACTERIZE THE MAJOR FEATURE OF EACH MIXTURE OF SOVIET WEAPONS.

2/ FOR EACH CASE (PARTICULAR NUMBER OF U.S. WEAPONS AGAINST PARTICULAR SOVIET POSTURE) THE U.S. WEAPONS ARE OPTIMALLY TARGETED AGAINST THE SOVIET FORCE TO MINIMIZE THE U.S. FATALITIES WHICH CAN BE PRODUCED BY THE SURVIVING FORCE. THE PLOTTED POINTS ARE THE U.S. FATALITIES WHICH THEN RESULT FROM RETALIATORY EMPLOYMENT OF THE SURVIVING SOVIET FORCE.

3/ FATALITIES INDICATED ARE FROM DIRECT EFFECTS OF BLAST AND FALLOUT ONLY, AND DO NOT INCLUDE FIRESTORMS AND DELAYED EFFECTS. THEY THEREFORE REPRESENT LOWER LIMITS TO THE ULTIMATE FATALITIES FROM ALL CAUSES.

FIGURE 2
APPENDIX "E" TO
ENCLOSURE "A"
WSEG REPORT NO.

7-6-00-1DA

EFFECTIVENESS IN PREVENTING U.S. FATALITIES OF HYPOTHETICAL U.S. INITIATIVE ATTACKS ON REPRESENTATIVE SOVIET FORCE POSTURES

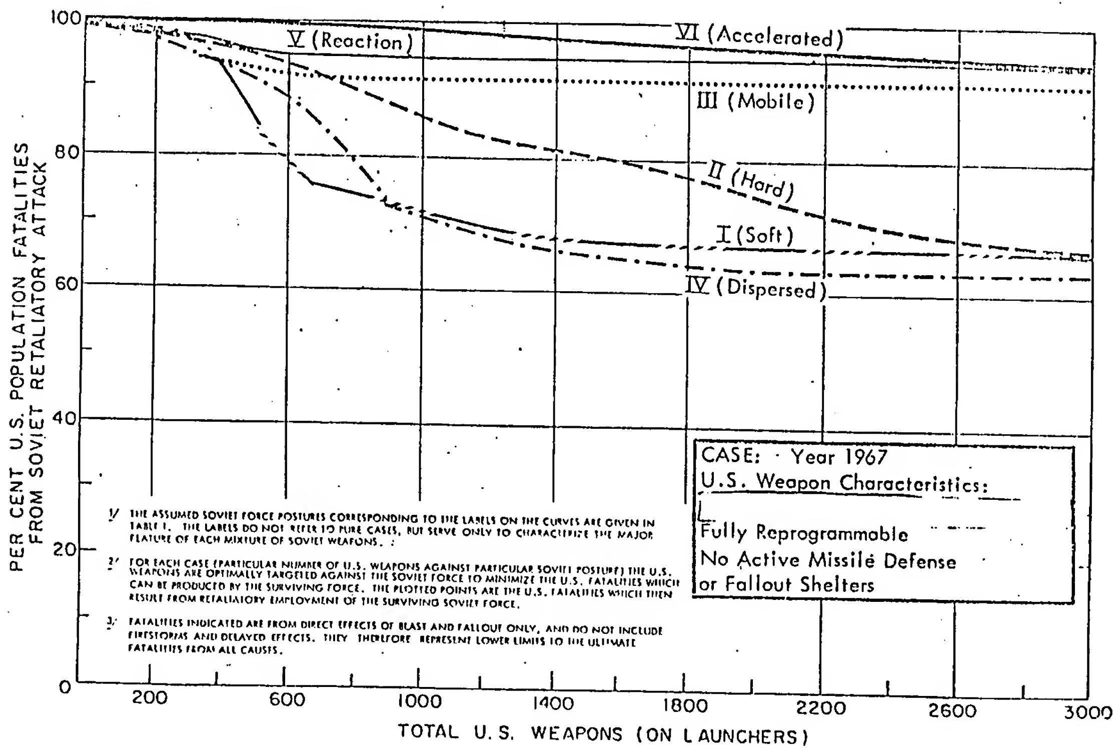


FIGURE 3
APPENDIX "F" TO
ENCLOSURE "A"
WSEG REPORT

7-6-60-11A

EFFECTIVENESS IN PREVENTING U.S. FATALITIES OF HYPOTHETICAL U.S. INITIATIVE ATTACKS ON REPRESENTATIVE SOVIET FORCE POSTURES

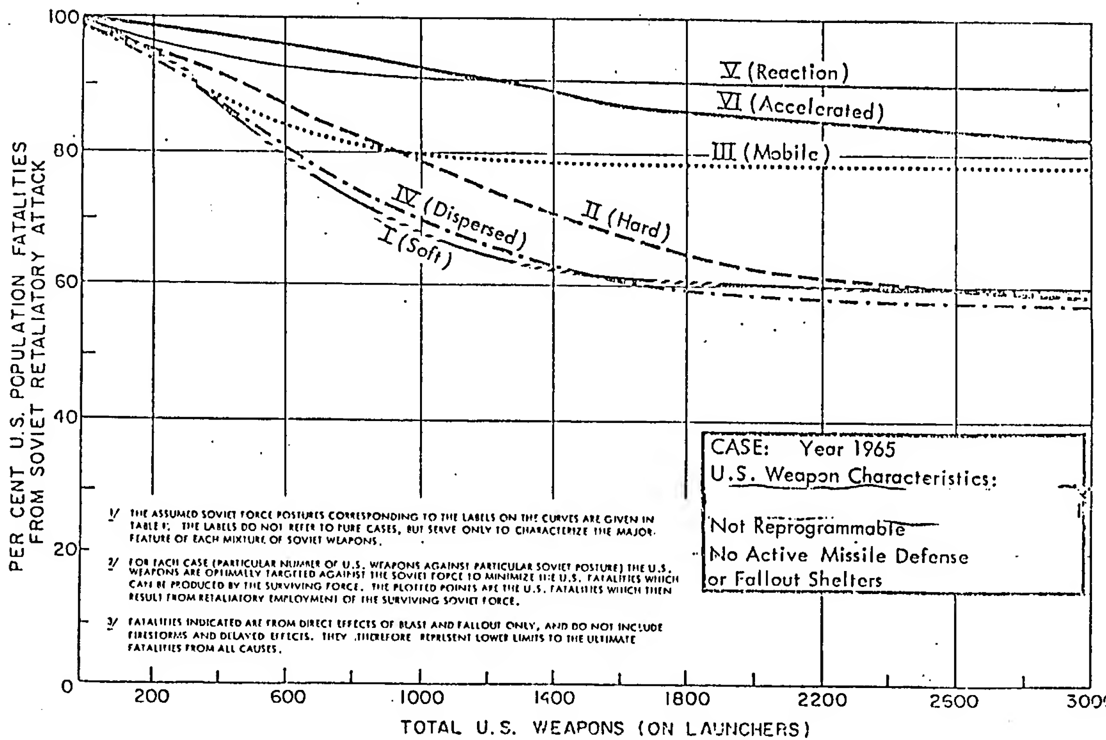
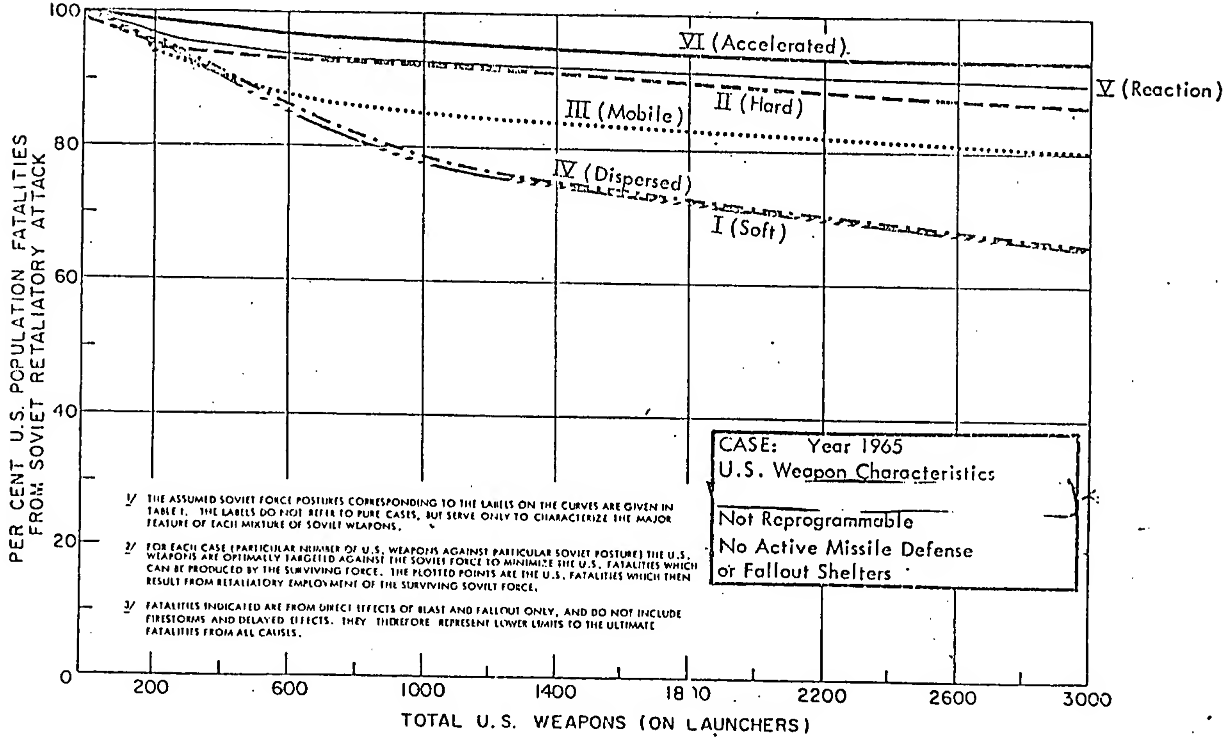


FIGURE 4
APPENDIX "E" TO
ENCLOSURE "A"
WSEG REPORT NO. 50

EFFECTIVENESS IN PREVENTING U.S. FATALITIES OF HYPOTHETICAL U.S. INITIATIVE ATTACKS ON REPRESENTATIVE SOVIET FORCE POSTURES



1/ THE ASSUMED SOVIET FORCE POSTURES CORRESPONDING TO THE LABELS ON THE CURVES ARE GIVEN IN TABLE I. THE LABELS DO NOT REFER TO PURE CASES, BUT SERVE ONLY TO CHARACTERIZE THE MAJOR FEATURE OF EACH MIXTURE OF SOVIET WEAPONS.

2/ FOR EACH CASE (PARTICULAR NUMBER OF U.S. WEAPONS AGAINST PARTICULAR SOVIET POSTURE) THE U.S. WEAPONS ARE OPTIMALLY TARGETED AGAINST THE SOVIET FORCE TO MINIMIZE THE U.S. FATALITIES WHICH CAN BE PRODUCED BY THE SURVIVING FORCE. THE PLOTTED POINTS ARE THE U.S. FATALITIES WHICH THEN RESULT FROM RETALIATORY EMPLOYMENT OF THE SURVIVING SOVIET FORCE.

3/ FATALITIES INDICATED ARE FROM DIRECT EFFECTS OF BLAST AND FALLOUT ONLY, AND DO NOT INCLUDE FIRESTORMS AND DELAYED EFFECTS. THEY THEREFORE REPRESENT LOWER LIMITS TO THE ULTIMATE FATALITIES FROM ALL CAUSES.

FIGURE 5
APPENDIX "E" TO
ENCLOSURE "A"
WSEG REPORT No. 50

simply to the non-targetable residues of the Soviet forces. These limits are, however, approached somewhat more slowly in this case. Figure 5 shows the effect of a further reduction in the quality of the U.S. offensive missile by assuming

and also no reprogramming.

31. Since the asymptotes of the figures do not depend upon the U.S. weapon characteristics, and also serve to measure the ultimate possibilities, the subsequent discussion will be concerned only with these limits. Table VI summarizes these ultimate limits for the various Soviet postures and the three time periods considered.

TABLE VI

PERCENT U.S. POPULATION FATALITIES FROM RETALIATORY EMPLOYMENT OF THE NON-TARGETABLE RESIDUE OF SOVIET FORCES (NO SHELTERS OR AICBM)

		YEAR		
SOVIET POSTURE		1963 (Percent)	1965 (Percent)	1967 (Percent)
I	(SOFT)	47	59	67
II	(HARD)	47	57	63
III	(MOBILE)	--	78	91
IV	(DISPERSED)	--	57	63
V	(FAST REACTION)	82	90	94
VI	(ACCELERATED)	47	81	94

32. From Table VI it is seen that in the most favorable case the U.S. could suffer 47 percent population fatalities while in the fast reaction, mobile, or accelerated cases in which a larger fraction of the Soviet force is not targetable, the U.S. fatalities range from nearly 80 percent to 94 percent of the total population.

33. Since the assumptions upon which Table VI are based have been deliberately chosen favorable to U.S. initiative counterforce -- the fatality estimates are lower bounds, 90 percent of fixed Soviet ICBM bases were assumed to be targetable, and complete destruction of all targetable forces was assumed -- the outcome of any realistic case is likely to be a good deal worse.

34. It is clear from these results that (in the absence of an effective civil defense program and/or ballistic missile active defense) the prospects of a satisfactory outcome from a U.S. initiative attack are not good. The next section investigates the potential contribution of active and passive defense.

CONTRIBUTION OF PASSIVE AND ACTIVE DEFENSE MEASURES

35. In order to illustrate the potential contribution of fallout shelters to blunting the effectiveness of a Soviet retaliatory attack, the calculations of Table VI have been repeated for the case of the U.S. population fully sheltered according to the assumptions of Appendix "D". The results of this calculation are presented in Table VII. Table VII thus presents percentage of U.S. population fatalities which might be expected from the retaliatory employment of the non-targetable residue of Soviet forces against a sheltered U.S. population, but without any active ballistic missile defense.

TABLE VII

PERCENT U.S. POPULATION FATALITIES FROM RETALIATORY EMPLOYMENT OF THE NON-TARGETABLE RESIDUE OF SOVIET FORCES FOR THE CASE OF FULLY SHELTERED a/ U.S. POPULATION (NO AICBM)

SOVIET POSTURE		YEAR		
		1963 (Percent)	1965 (Percent)	1967 (Percent)
I	(SOFT)	26	33	39
II	(HARD)	25	32	36
III	(MOBILE)	--	48	59
IV	(DISPERSED)	--	32	36
V	(FAST REACTION)	50	57	62
VI	(ACCELERATED)	26	50	62

a/ For shelter assumptions, see Appendix "D".

36. It is clear from Table VII that provision of fallout shelters to the U.S. population causes a further reduction in the casualties (beyond the reduction due to the U.S. counterforce attack) to be expected from the employment of the residual

Soviet forces. The reduction in fatalities ranges from 22 percent to 33 percent of the entire U.S. population, which represents a saving of about 40 million to 60 million lives.

37. In order to properly assess the significance of this calculation, it is necessary to bear in mind certain features of the assumed shelter program. In the first place, the effectiveness of the shelters was deliberately chosen conservatively in order to approximate a lower bound to the effectiveness which might be realized by a fallout shelter program. No provision was made for the employment of decontamination procedures upon exit from the shelters, nor were sufficient stocks of food and water supplied to last for more than a month or so. These measures could significantly increase the effectiveness of the shelter program.

38. In addition, no allowance has been made for the possibility of a fallout shelter program designed to shelter only a part of the entire U.S. population. By optimally choosing the geographic regions of the United States in which to apply sheltering, the number of lives potentially saved for a given cost could be considerably greater than for the case in which the entire U.S. population is sheltered. With these considerations the costs of saving lives by fallout sheltering implied by Table VII ($900 to $1400 per life saved based on a conservative estimate of $300 per person sheltered) may properly be regarded as overestimates. For the optimal deployment of a partial shelter program, the cost per life saved might approach the basic cost per person sheltered.

39. For purposes of assessing the potential contribution of active ballistic missile defense to blunting the effectiveness of a Soviet retaliatory strike, it is only necessary to observe that active missile defenses perform the same function in this respect

[redacted]

as strategic offensive weapons employed in the counterforce role; namely, the reduction in the number of weapons impacting in the United States. Since this is the case, offensive weapon systems and active defenses can be considered to be direct competitors for purposes of blunting enemy attacks and may be compared on a basis of cost per enemy weapon killed independently of the assumptions of fallout sheltering and of the actual fatality level produced.

40. In order to gain some appreciation for the order of magnitude of the costs per unit enemy warhead killed by offensive missile systems, Tables VIII and IX present these costs for two different exemplary U.S. missile systems. Table VIII presents the cost per expected deliverable warhead kill for a hypothetical U.S. ICBM

Since the returns progressively diminish as more than one weapon is assigned to the same target, these costs are presented as the costs associated with each successive weapon assigned to the target. The costs are presented for each major type of target considered in the representative Soviet force posture.

TABLE VIII

COST ($ MILLION) PER EXPECTED DELIVERABLE WARHEAD KILL FOR A FULLY REPROGRAMMABLE ICBM COSTING 10 MILLION DOLLARS a/ b/

Counterforce Weapon Assigned to Target	TARGET			
	Soft 3/Aim Point Soviet ICBM ($ Millions)	Soft 1/Aim Point Soviet ICBM ($ Millions)	100 psi Soviet ICBM ($ Millions)	300 psi Soviet ICBM ($ Millions)
1st Weapon	6.4	19.0	22.4	35.6
2nd Weapon	158.0	475.0	121.0	73.1
3rd Weapon	3,960.0	11,900.0	655.0	150.0

a/ Assumptions:

Soviet ICBM reliability 0.75.

b/ In the "fast reaction" case, all costs should be doubled to reflect the fact that 50 percent of the Soviet force is launched prior to impact of U.S. ICBM's.